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PPRP

Habitat Assessment of the Potomac River From Little Falls to Seneca Pool

September 2003

MARYLAND POWER PLANT RESEARCH PROGRAM

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FINAL

HABITAT ASSESSMENT OF THE POTOMAC RIVER FROM LITTLE FALLS TO SENECA POOL

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FOREWORD

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ABSTRACT

A current multi-agency agreement establishes a Potomac River minimum low-flow requirement (100 million gallons per day or mgd) or flow-by at Little Falls and a recommended operational guideline of 300 mgd flow-by at Great Falls. The Maryland Department of Natural Resources (DNR) has initiated a re-evaluation of the low-flow requirements for protecting the lower Potomac River aquatic ecosystem near Washington, D.C. This report provides background information describing the history of current low-flow requirements, a review of the studies conducted to support those requirements, and results of a habitat assessment conducted during record low flow conditions in 2002. The assessment included development of a habitat map, a field survey of habitat types, and measurements of hydraulic and water quality conditions, spanning the period July through October 2002 when flows were as low as 151 million gallons per day at the gage at Little Falls Dam.

EXECUTIVE SUMMARY

A current multi-agency agreement establishes a Potomac River minimum low-flow requirement (100 million gallons per day or mgd) or flow-by at Little Falls and a recommended operational guideline of 300 mgd flow-by at Great Falls. The Maryland Department of Natural Resources (DNR) has initiated a re-evaluation of the low-flow requirements for protecting the lower Potomac River aquatic ecosystem near Washington, D.C. The Potomac Flow-by Committee involving resource agencies, environmental organizations, water utility representatives, and other parties was formed to provide guidance for this re-evaluation. A subcommittee, the Habitat Assessment Subcommittee (HAS), was established to oversee the technical aspects of this re-evaluation and provide an assessment of issues and proposed activities to the full committee. This report provides background information describing the history of current low-flow requirements, a review of the studies conducted to support those requirements, and a report on habitat assessment conducted during low flow conditions in 2002.

HAS discussed and reviewed a number of different approaches to improve the basis on which low-flow requirement decisions could be made. A number of modeling and analysis approaches were reviewed for their advantages and disadvantages in evaluating habitat flow requirements for the lower Potomac but none were found suitable. Fortuitously, at the time a re-evaluation was being considered, record drought conditions began in the spring of 2002, which presented an opportunity to conduct a physical habitat assessment, including developing a habitat map, conducting a field survey of habitat types, and measuring hydraulic and water quality conditions. This assessment spanned July through October 2002 when flows were as low as 151 mgd (233 cfs) at the Little Falls gage.

On April 8-9, 2003, the HAS convened a workshop with a special panel of nationally recognized experts on habitat assessment methods to investigate and develop a method to evaluate the environmental flow-by requirements. At this workshop, members of the special panel collectively considered and debated the various methodologies applicable to the Potomac River to address the objectives listed in Section 1.3. The final product of the workshop is a set of recommendations to the HAS for 1) the best method or approach, given current financial resource limitations, to address the Potomac Flow-by Study objectives, and the level of confidence associated with their conclusion, and 2) an alternative long-term method or approach which could better accomplish those objectives, yet might exceed current resources or available data, and recommended guidelines for achieving the objectives in a longer time-frame.

New record low flows occurred in Spring 2002 and low flow conditions in the summer months approached record lows. Water supply releases were made on a total of 38 days in 2002, as compared with a total of 26 days in 1999; no water supply releases had been made prior to 1999. The low flows in 2002 enabled the PPRP habitat team to make successful assessments over several months during rare low flow conditions. Results of water level recordings showed the greatest change in stage with changes in flow at Lock 8 and Old Angler's Inn, and smaller changes at Carderock and Little Falls Dam. A reduction in flow from 500 mgd (770 cfs) to 300 mgd (465 cfs) resulted in the following relatively small reductions in water level: 2.2 inches at Carderock, 3.6 inches at Old Angler's Inn, 3.9 inches at Lock 8, and 1.6 inches at Little Falls Dam.

Results of temperature measurements show that very high temperatures occurred at flows well above the current recommended minimum flow-by level and were probably more related to air temperature and solar radiation than to any particular flow level below about 970 mgd (1500 cfs). Measurements of dissolved oxygen for a one-week period in August showed lowest levels occurring in two of the largest pool areas of the river (Little Falls Dam and Seneca Pool) which were at or slightly below the Maryland state standard of 5 mg/l. However, the low values did not correspond to lowest flow values which occurred during this short measurement period. Dissolved oxygen values in two other pool areas (Aqueduct Dam and Old Angler's Inn) were never lower than 7 mg/l during this measurement period.

Results of macrohabitat surveys confirmed the very diverse nature of habitats in the study reach. There is a predominance of Pool habitat (37%), followed by Shallow Run (24%), and Deep Run (19%) habitats. Results of microhabitat surveys indicate some very deep areas in the study reach. The pool beneath the American Legion Bridge is quite deep, averaging over 20 feet overall, 40 feet in the main channel, and reaching 94 feet at its maximum depth. Mather Gorge and Old Angler's Inn Pool are both also relatively deep, with average main channel depths 23 and 22 feet, respectively, and with maximum depths of 45 and 36 feet, respectively. The remaining large pool areas (above Little Falls Dam, above Aqueduct Dam and Seneca Pool) are relatively shallow, with maximum depths less than 15 feet and average depths less than 8 feet.

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1.0 INTRODUCTION

1.1 BACKGROUND

A current multi-agency agreement establishes a Potomac River minimum low-flow or flow-by requirement (100 million gallons per day [mgd]; 155 cubic feet per second [cfs]) at Little Falls and a recommended operational guideline of 300 mgd (464 cfs) flow-by at Great Falls (see location map, Figure 1-1). These flow requirements were established over 20 years ago. The severe drought conditions that occurred in the Potomac River watershed in 1999 raised concerns about the adequacy of this minimum low-flow requirement for protecting the river ecosystem and its resources, particularly given the increasing demand for water within the river basin. The Maryland Department of Natural Resources (DNR) agreed to coordinate an assessment of natural resource issues and conduct an evaluation of whether the current minimum low-flow requirement adequately protects natural resources from irreversible long-term or significant short-term impacts. The Power Plant Research Program (PPRP) of DNR serves as lead agency for this effort given its involvement with a preliminary permit for licensing of a hydroelectric project at Jennings-Randolph reservoir and its evaluation of potential power plants with new water intakes on the Potomac River in Frederick and Montgomery Counties. In addition, PPRP served as the Maryland agency in evaluating and establishing minimum flow requirements below Conowingo Dam on the Susquehanna River. As part of the low-flow assessment and evaluation, several meetings were held in 2000 among interested stakeholders (The Potomac Flow-by Committee) to discuss potential impacts on natural resources due to low flows. A subset of stakeholders, including local, state, and federal agencies, water supply utilities, and environmental groups, was set up as a Habitat Assessment Subcommittee (HAS) to focus on flow-related habitat issues.

The low-flow requirements for the Potomac were set in the 1980s as a result of an assessment study entitled, *Potomac River Environmental Flow-By Study*. The study was completed in 1981 by the Maryland Department of Natural Resources, Water Resources Administration (currently, the Water Management Administration, Maryland Department of the Environment), Water Supply Division. The study was required as part of the Potomac River Low-Flow Allocation Agreement (LFAA) signed in 1978, which governs water utility utilization of Potomac River water. The agreement specifies that if unrestricted water demand in the Washington metropolitan area exceeds the available flow in the Potomac, the LFAA determines how much water each utility is allowed to appropriate. Signatories to the LFAA include the United States of America (Secretary of the Army), State of Maryland, Commonwealth of Virginia, District of Columbia, Fairfax County Water Authority, and Washington Suburban Sanitary Commission. To augment natural flows in the river, water releases from several impoundments in the basin are determined and requested by the Interstate Commission on the Potomac River Basin (ICPRB), with oversight by an operations committee of the Washington metropolitan area water suppliers.

A presentation by ICPRB in March 2000 showed how the current flow-by recommendations were implemented during the drought of 1999. The presentation described the water utility service areas in the Washington metropolitan area in 2000 and the resources available to supplement water supplies and flow in the Potomac during drought periods. Water withdrawals and flow shifts under various river flow scenarios were described and an illustration of the river flows that would have occurred in 1999 without a release from Jennings-Randolph reservoir was presented (Figure 1-2). Figure 1-3 shows the locations of the Washington metropolitan area water supply reservoirs.

During their initial meetings, the HAS members agreed that the 1981 flow-by study should be revisited in light of its inherent and recognized shortcomings, to review the potential availability of new information and techniques to study flow-related habitat conditions, and to address the fact that the original study was not able to evaluate physical habitat at flows lower than about 900 mgd (~1400 cfs). Because river flow did not drop below 900 mgd when the study was performed, conclusions regarding consequences to aquatic habitat from flows lower than that amount were based on extrapolations.

1.2 REVIEW OF 1981 FLOW-BY STUDY

The decision to initiate a new study of low-flow requirements was prompted in part by a review of the work that served as the basis for the current flow-by standards agreement. HAS members reviewed the 1981 study but were unable to discern whether there was a biological or environmental basis for the recommended 100/300 mgd (155/464 cfs) minimum flow-by. As stated in the 1981 report:

> "A daily average flow below Little Falls Dam of 100 mgd is nearly the limit of what the current system can provide during extreme drought conditions... By gradually shifting Aqueduct withdrawals to the Little Falls Dam intake when 500 mgd is observed just above the Great Falls intake, up to an additional 200 mgd would be available for environmental purposes down to the dam."

HAS also determined that although the Instream Flow Incremental Methodology (IFIM) (the analysis method employed in the 1981 study; see Appendix A) could have been used to evaluate the potential fisheries impacts at various flow levels, the report did not explicitly indicate any linkage between the recommended 100/300 mgd minimum flow and the IFIM or other biological and environmental results presented. Results of the 1981 IFIM (using the Physical Habitat Simulation Model; see Appendix A) were examined to determine the extent to which they did support the minimum flow that was selected. This evaluation showed that habitat for all but one (bluegill) of the six species selected for analysis in the 1981 report would decline as flows dropped from 1800 mgd (2785 cfs) (extrapolated) down to 300 mgd (464 cfs) (the lower limit of the evaluation at that time because of the lowest measured flow). These data imply that, with the exception of habitat for bluegill, *any increase in flow would result in an increase in habitat*. However, the 1981 IFIM work was limited by lack of low-flow data. The lowest measured flow during the study was about 900 mgd (~1400 cfs). IFIM results were then extrapolated to estimate results at 300 mgd between Little Falls Dam and Great Falls. The validity of the extrapolated findings is not known and could not be established from the information in the report. Maryland Department of Environment records were searched for data that were used in the 1981 IFIM analyses. Although some data were located and acquired, those data were insufficient for any more detailed or targeted habitat assessment, thus suggesting that collecting new, additional data would be necessary. Uncertainty about the rate of habitat decline with decreasing flow under low-flow conditions could thus be reduced by repeating the 1981 study when the Potomac River flows were lower than 900 mgd and closer to the current minimum flow recommendation of 300 mgd.

HAS and others identified additional shortcomings of the original 1981 study.

- The IFIM approach, at that time, had never been applied to a river as large or complex as the Potomac; as a result, data collection was, to some extent, trial-and-error. Some of the data collected had to be discarded or significantly adjusted because of lack of consistency in the manner in which it was collected, and the amount of data collected was insufficient for thorough analysis of all habitat types. These difficulties in data collection resulted in only four of the 12 transects being used to calculate habitat suitability for various flow levels.

- Horizontal distances between stations at each transect were not measured in a consistent manner from year to year, which resulted in site-specific data not being consistently represented in the different years of study.

- The study design did not use a habitat mapping approach to properly select locations for transects, and transect data were not weighted appropriately for analysis.

- IFIM is intended for use on heavily and permanently regulated rivers and is thus inappropriate to evaluate infrequent extreme drought conditions.

1.3 MANAGEMENT OBJECTIVES OF A NEW FLOW-BY STUDY

The objectives of a new flow-by study are as follows:

- estimate the amount and quality of biotic habitat available at different flow levels, particularly as it relates to the current minimum flow-by requirement; and

- determine what instream flows are required to provide adequate aquatic habitat and to prevent a reduction of any representative important species beyond levels from which it cannot recover and re-colonize the area following a drought event.

1.4 METHODS FOR ASSESSING HABITAT UNDER LOW FLOW CONDITIONS

After considering the deficiencies evident in the 1981 study, HAS discussed and reviewed a number of different approaches to improve the basis on which low-flow requirement decisions could be made. Initially, the HAS sought to repeat an IFIM study, using updated and improved data collection and analytical techniques. A second method considered was the Riverine Community Habitat Assessment and Restoration Concept (RCHARC). RCHARC is a simulation approach for relating the effects of flow alterations and alternative channel designs on aquatic biota. A third possible method was a non-modeling, statistical approach for evaluating changes in river hydrology that could affect the river's ecology. Appendix A provides a summary and review of the advantages and disadvantages of these and several other potential analysis approaches for addressing environmental flow-by issues in the freshwater Potomac River.

The drought conditions which occurred in 2002 presented an opportunity to conduct at least a portion of a physical habitat assessment under low flow conditions, including developing a habitat map, conducting a field survey of macro- and micro-habitat, and measuring water levels and water quality parameters. Although no method has been selected for evaluating the environmental flow-by, the information collected under these rare drought conditions should enable a better design of such a method at some later time. The reach to be surveyed was defined by Maryland DNR as extending from Little Falls at the head of tide upstream to Seneca Pool.

On April 8-9, 2003, the HAS convened a workshop with a special panel of nationally recognized experts on habitat assessment methods to investigate and develop a method to evaluate the environmental flow-by requirements. At this workshop, members of the special panel collectively considered and debated the various methodologies applicable to the Potomac River to address the objectives listed in Section 1.3. The final product of the workshop is a set of recommendations to the HAS for 1) the best method or approach, given current financial resource limitations, to address the Potomac Flow-by Study objectives, and the level of confidence associated with their conclusion, and 2) an alternative long-term method or approach which could better accomplish those objectives, yet might exceed current resources or available data, and recommended guidelines for achieving the objectives in a longer time-frame. A report on the workshop and the panel recommendations are provided at the website:

http://esm.versar.com/pprp/potomac/workshop/workshop.htm

2.0 HYDROLOGY AND WATER QUALITY

2.1 SUMMARY HYDROLOGY AND WATER SUPPLY WITHDRAWALS

Tables 2-1 and 2-2 present a summary of flow statistics for the Potomac River gage at Little Falls Dam based on the period of record and other analysis. They show how the current flow-by requirements compare with low flow events during the period of record for this gage. Table 2-3 and Figure 2-1 show the flow duration curve and data for the Little Falls gage (unadjusted for water withdrawals) for the period of record. These results show that the current recommended flow-by below Great Falls of 300 mgd (465 cfs) is well below the 99th percentile flow of 663 cfs (the flow that has been exceeded 99 percent of the days during the period of record).

Table 2-1. Flow statistics for the Little Falls pumping station gage (USGS No. 01646500) in the lower freshwater portion of the Potomac River. Sources: All but 7Q10 from Water Resources Data Maryland and Delaware Water Year 2001, USGS Water-Data Report MD-DE-01-1, by R.W. James et al. 2002. 7Q10 data from Characteristics of Streamflow in Maryland, Report of Investigations No. 35, by D.H. Carpenter, 1983. Watershed area above Little Falls gage: 11,560 sq. miles. Watershed area above Luke, Savage, Seneca Creek stations: 613 sq. miles (representing impounded portion of watershed) or about 5% of the total.

Parameter	Flow, cfs	Flow, mgd
Record 24-hour average low flow, unregulated period (1930-1958): 25 Aug 1930 (unadjusted)	448	289
Record 24-hour average low flow, regulated period (1959-2001): 9 Sep 1966 (unadjusted)	121	78
Record 24-hour average low flow, regulated period (1959-2001): 9 Sep 1966 (adjusted for diversions)*	601	388
Annual 7-day minimum, unregulated period: 21 Aug 1930 (unadjusted)	499	322
Annual 7-day minimum, regulated period: 7 Sep 1966 (unadjusted)	181	117
7Q10, based on observed flow, 1930-1979 (unadjusted)	606	391
7Q10, based on diversion-adjusted flow, 1930-1979*	1010	652
Mean annual flow (unregulated period, 1930-1958; unadjusted)	10790	6961
Mean annual flow (regulated period, 1959-2001; unadjusted)	11640	7523
Alert stage flow (assuming 500 mgd withdrawals): 50-80% of total daily flow	1550-930	1000-625
Restriction stage flow (assuming 500 mgd withdrawals): > 80% of total daily flow	< 930	< 625

* "Adjusted for diversions" is the flow that would have occurred without Washington metropolitan area water supply withdrawals.

Table 2-2. Low mean daily flow values for the Potomac River at Little Falls (unadjusted for water withdrawals) for the indicated number of consecutive days, for low flow and recent years. USGS program SWSTAT used to calculate these statistics for the period of record 1 Mar 1930 to 30 Sep 2002.

Calendar Year	1-day		7-day		30-day		60-day		90-day	
	cfs	mgd	cfs	mgd	cfs	mgd	cfs	mgd	cfs	mgd
1930	448	289	499	322	564	364	623	402	817	527
1966	121	78.1	181	117	442	285	446	288	718	463
1999	174	112	303	195	429	277	563	363	874	564
2001	948	612	1160	748	1730	1116	3530	2277	3510	2265
2002	257	166	326	210	803	518	1040	671	1120	723

Table 2-3. Table of values for the flow duration curve of the Potomac River at Little Falls (unadjusted), for the period of record 1 Mar 1930 to 30 Sep 2002.

Percent	Flow, cfs	Flow, mgd
1	77173	49789
2	57833	37311
5	37892	24446
10	25574	16499
15	19514	12589
20	15945	10287
25	13414	8654
30	11256	7261
35	9762	6298
40	8440	5445
45	7374	4757
50	6366	4107
55	5510	3554
60	4716	3042
65	4014	2589
70	3441	2220
75	2926	1887
80	2467	1591
85	2038	1314
90	1625	1048
95	1195	770
98	858	553
99	663	427

2.2 2002 DROUGHT FLOWS

Figures 2-2 and 2-3 show the daily flow record for the Little Falls gage in 2002 (before water supply withdrawals, through mid-October) in comparison with the period of record flow statistics. Although new record lows occurred in spring of that year, low flow conditions in the summer months approached but did not reach record lows. However, flows did reach the water supply demand levels plus the 100 mgd flow-by. Water supply releases are listed in Table 2-4. Figures 2-4 to 2-6 show the unadjusted hourly flow record for the Little Falls gage from July through September 2002, in comparison with the Little Falls pump station withdrawals, for periods when flows were less than 1000 cfs. Also shown are the flows estimated to occur above Little Falls gage, calculated by adding the pumpage flows to the gaged flows. This is an estimate of flows that occurred from above Great Falls (the location of the next most upstream withdrawal location) downstream to the Little Falls pump station withdrawal. (Since the gage records at Little Falls may have been affected by the withdrawals, upstream flow estimates were not made for a period of 6 hours after withdrawals were stopped.) Flows never dropped below 100 mgd at Little Falls Dam but did decrease below 300 mgd for several days during summer 2002. Figure 2-7 shows the daily flow record for the Little Falls gage in comparison with 1) the flow record adjusted for metropolitan area water supply withdrawals, and 2) an estimate of the natural flow that would have occurred without any upstream reservoir regulation or metropolitan area water supply withdrawals. The lowest estimated natural flow on a daily basis was about 400 mgd, as compared with the record low flow in 1930 of 289 mgd.

Table 2-4. Water supply releases in 2002 and 1999 made from Jennings-Randolph and Seneca reservoirs. Note: Travel time to the lower Potomac from Jennings Randolph and Seneca is approximately 9 days and 1 day, respectively.

	Jennings Randolph Water Supply Release in 2002, mgd	**Seneca Water Supply Release in 2002, mgd**		**Jennings Randolph Water Supply Release in 1999, mgd**	**Seneca Water Supply Release in 1999, mgd**
11-Jul-2002	0	0	11-Jul-1999	360	0
12-Jul-2002	0	10	12-Jul-1999	360	0
13-Jul-2002	0	65	13-Jul-1999	200	0
14-Jul-2002	0	25	14-Jul-1999	100	0
13-Aug-2002	0	10	15-Jul-1999	100	0
14-Aug-2002	0	35	16-Jul-1999	200	22
15-Aug-2002	0	35	17-Jul-1999	200	0
16-Aug-2002	79	47	18-Jul-1999	100	0
17-Aug-2002	0	45	19-Jul-1999	100	0
19-Aug-2002	187	15	20-Jul-1999	100	0
20-Aug-2002	270	86	21-Jul-1999	50	0
21-Aug-2002	270	78	22-Jul-1999	50	0
22-Aug-2002	230	25	23-Jul-1999	50	0
23-Aug-2002	230	0	24-Jul-1999	50	0
24-Aug-2002	230	0	25-Jul-1999	50	0

Table 2-4. Continued

	Jennings Randolph Water Supply Release in 2002, mgd	Seneca Water Supply Release in 2002, mgd		Jennings Randolph Water Supply Release in 1999, mgd	Seneca Water Supply Release in 1999, mgd
25-Aug-2002	196	0	26-Jul-1999	50	0
26-Aug-2002	161	0	27-Jul-1999	31	0
27-Aug-2002	161	0	28-Jul-1999	25	0
28-Aug-2002	161	0	29-Jul-1999	12	0
29-Aug-2002	109	0	11-Aug-1999	120	0
30-Aug-2002	109	0	12-Aug-1999	171	0
31-Aug-2002	109	0	13-Aug-1999	150	0
6-Sep-2002	120	0	14-Aug-1999	120	0
7-Sep-2002	120	0	15-Aug-1999	120	0
8-Sep-2002	120	0	16-Aug-1999	120	0
9-Sep-2002	240	75	17-Aug-1999	60	0
10-Sep-2002	240	125			
11-Sep-2002	187	100			
12-Sep-2002	187	50			
13-Sep-2002	187	100			
14-Sep-2002	187	50			
15-Sep-2002	135	0			
16-Sep-2002	135	0			
17-Sep-2002	135	0			
18-Sep-2002	135	0			
19-Sep-2002	135	0			
20-Sep-2002	135	0			
21-Sep-2002	103	0			
22-Sep-2002	103	0			
Sum	**7108**	**2968**		**4328**	

2.3 STAGE-DISCHARGE RELATIONSHIPS

2.3.1 Methods

Water level measurements were made at several locations (Table 2-5, Figures 2-8 and 2-9) in the study reach to evaluate stage changes during low flow conditions. Locations were selected to represent a variety of habitats in the study reach but had to be relatively close to access points due to the logistics of deploying and servicing the equipment. The continuous data provided a long-term database of water levels which could then be correlated with the stage-discharge relationship established at the USGS gage at Little Falls Dam to provide an estimate of flow.

Automated bubbler-type ISCO Model 4230 ISCO Flowmeters were used to record water levels. The flowmeter is able to store up to 40 days of continuous level data which is digitally recorded at 5-minute intervals. The ISCO equipment was powered by a single deep-cycle marine battery (e.g., Exide "Prevailer" Model PV-27DC). These battery types are able to provide power to the field equipment for up to two months at a time before recharge is necessary. The bubbler line was secured to prevent movement by high water flows and thus maintain accurate level measurements. The line was anchored to “rebar” via cable tie and concealed/buried as far as was possible in the local substrate to prevent damage to the plastic bubbler by wildlife or other causes. The flowmeter equipment was secured in a weather-proof plastic box which was secured to a nearby tree with chain and a weather-resistant coated padlock. Equipment was checked approximately biweekly and data downloaded in case of later equipment failure or vandalism. Data were discarded if the bubbler line became detached or if the water level receded below it.

Table 2-5. Locations of stage recorders in the Potomac flow-by study reach in 2002. See Figure 2-8 for map of station locations.

Location Name	Dates of Deployment	Nearest Transect*	Coordinates
Lock 8	July 2 - October 7	36	38.97025 N 77.16159 W
Carderock	July 2 - September 10	55	38.96977 N 77.19740 W
Old Angler’s Inn	July 3 - October 7	78A	38.98033 N 77.23200 W
Swain’s Lock	September 11 - October 7	122	39.03017 N 77.24410 W

* See Appendix B for transect locations

2.3.2 Results

Figures 2-10 through 2-12 show water levels at the stations listed in Table 2-5 during July, August, and September 2002, respectively. (The starting elevations for each station represent an arbitrary relative local water depth and are not related to the average water depth at that location in the river channel.) Shown for comparison is the stage and corresponding discharge at the USGS Little Falls pumping station gage (No. 01646500). Also shown are the pump flows at the Little Falls pump station during this period. Water levels recorded at this gage are affected by water withdrawals at the pump station and thus reflect the discharge below Little Falls Dam. Due to hydrologic inertia in the pool behind Little Falls Dam, stage records may be affected by withdrawals at that location for as long as 6 hours after withdrawals are stopped (Erik Hagen, ICPRB, personal communication). Thus, to derive an approximate stage-discharge relationship for the other stations, a dataset was created which included only stage records outside of 1 hour prior to and 6 hours after withdrawals stopped at Little Falls pump station (Figure 2-13); the lowest discharge which occurred within this dataset was 233 cfs (151 mgd), which is the lowest recorded flow in 2002, in the absence of withdrawals from Little Falls pumping station, and thus presents the minimum flow-by which occurred in that period between Great Falls and Little Falls Dam. A subset of these data were then used with a power curve-fit function within Excel to derive a stage-discharge relationship (Figure 2-14). Data were selected for a period when discharge at Little Falls was less than 700 cfs and there was only a gradual change in stage (August 13-18, 2002), since this method assumes that discharge at the Little Falls gage represents flow at upstream stations, when no withdrawals were occurring at Little Falls. This method also assumes that there are not significant flows entering the river between the upstream gage stations and the Little Falls gage, and that changes in stage are instantaneous throughout the reach for the selected period. Under all these assumptions, the stage-discharge relationships are shown in Figure 2-15. (Appendix C describes direct discharge measurements made at selected transects.)

Table 2-6 summarizes the change in stage at various locations based on the stage recorder results for 2002. The lowest recorded flow in the August 13-18, 2002 dataset used for the stage-discharge calculation was 381 cfs. The current recommended flow-by from Great Falls to Little Falls Dam is 465 cfs (300 mgd). An arbitrary flow value for providing a comparison of stage changes at various locations with the current flow-by recommendation in that river reach is 770 cfs (500 mgd). These results show the greatest change in stage at Lock 8 and Old Angler's Inn, and smaller changes at Carderock and Little Falls Dam.

Table 2-6. Change in river stage during low flow conditions in the Potomac River based on measured stage records at various locations and flows measured at the Little Falls gage, corrected for withdrawals at the gage station.

Location	Stage change in inches from 381 to 465 cfs (246 to 300 mgd)	Stage change in inches from 465 to 770 cfs (300 to 500 mgd)
Old Angler's Inn	1.3	3.6
Carderock	0.8	2.2
Lock 8	1.4	3.9
Little Falls Dam	0.6	1.6

3.0 WATER QUALITY

3.1 METHODS

Temperature loggers were deployed from July through October 2002 at several locations in the study area to assess thermal responses of the river to low flow conditions. Onset StowAway TidbiT (Bourne, MA; www.onsetcomp.com) temperature loggers were used for this purpose and were set to record at 30-minute intervals. Resolution and accuracy of these thermistors is about 0.2°C. Table 3-1 shows the locations and dates of deployment for the temperature loggers.

Table 3-1. Locations of temperature loggers in the Potomac flow-by study reach in 2002. See Figure 2-8 for map of station locations.

Location Name	Dates of Deployment	Nearest Transect	Coordinates
Little Falls	July 2 - October 8*	4	38.93322 N 77.11784 W
Lock 8	August 1 - October 7*	36	38.97025 N 77.16159 W
Carderock	July 2 - October 10	55	38.96977 N 77.19740 W
Old Angler's Inn	July 3 - October 7	78A	38.98033 N 77.23200 W
Seneca Pool	July 3 - October 7	179	39.0685 N 77.33803 W

* Little Falls logger lost sometime in July; replaced August 2. Data from Lock 8 lost in July due to a faulty data download; data lost from Carderock, Old Angler's Inn, and Seneca Pool from July 31 to August 7 due to faulty deployment. Loggers were placed where water was about 1 foot deep on the date of deployment.

To assess potential changes in dissolved oxygen during low flow conditions, Hydrolab or YSI in-situ instruments were deployed during summer in several pool areas within the study area. Table 3-2 shows the locations and dates of deployment for the in-situ water quality monitors.

Table 3-2. Locations of in-situ water quality instruments in the Potomac flow-by study reach in 2002. See Figure 2-8 for map of station locations.				
Location Name	**Dates of Deployment**	**Nearest Transect**	**Coordinates**	**Approx. Depth, Feet**
Little Falls Pool	August 20-23, 27-30	18	38.9551 N 77.1334 W	9
Old Angler's Inn Pool	August 26-30	78A	38.98033 N 77.2320 W	18
Aqueduct Dam Pool	August 26-30	102	39.00097 N 77.24873 W	4
Seneca Pool	August 21-23, 27-30	179	39.0685 N 77.33803 W	5

3.2 RESULTS

3.2.1 Temperature

Figure 3-1 presents results for temperature loggers at several stations in the Potomac River in the study area in 2002 in comparison with discharge as recorded at the Little Falls USGS gage. Figures 3-2 through 3-7 present these results for the individual stations. Table 3-3 lists dates of maximum temperature values recorded by these loggers during the time periods of data collection listed in Table 3-1. These results show that very high temperatures occurred well above the current recommended minimum flow-by level and were more related to air temperature and solar radiation than to any particular flow level in this lower flow range (Figure 3-3). A multiple regression analysis was performed on the maximum daily water temperature at Little Falls Dam, the daily minimum and maximum air temperature at National Airport, and mean daily flow at Little Falls Dam. Results show partial R-squares of 0.80, 0.04, and 0.001 for minimum air temperature, maximum air temperature and mean discharge, respectively, indicating the greatest correlation with minimum air temperature.

3.2.2 Dissolved Oxygen and pH

Figures 3-8 thru 3-10 present results for in–situ dissolved oxygen and concomitant temperature and pH measurements during a short period in August 2002; flow as measured at the USGS Little Falls pumping station gage is shown for comparison. Table 3-4 lists dates, times, and flows of minimum dissolved oxygen values and pH ranges recorded during this period. Lowest dissolved oxygen levels occurred in two of the largest pool areas of the river and were at or slightly below the Maryland state standard of 5 mg/l. However, the low values did not correspond to lowest flow values which occurred during this short measurement period. Figure 3-10 presents pH measurements for the same time period in August. pH changes were generally less than 1 unit during the measurement period and were higher in areas where macrophytes were present (Little Falls Dam and Seneca Pool).

Table 3-3. Maximum temperatures recorded at various stations in the Potomac River in 2002, and corresponding flows at Little Falls gage. (Note: July data were lost for Little Falls and Lock 8 stations.)

Station	Date, Time	Temperature (C)	Flow, cfs
Little Falls	8/22/02, 1256-1611	30.9	325
Little Falls Dam (USGS)	7/4/02	32.8	1190 (daily average)
Lock 8	8/15/02, 1510	35.6	526
Carderock	7/4/02, 1600-1800	34.2	1150
Old Angler's Inn Pool	7/4/02, 1700-2230	33.6	1150
Seneca Pool	7/4/02, 1300	34.3	1090

Table 3-4. Minimum dissolved oxygen levels and range of pH in the Potomac River study area, measured between August 20 and 30, 2002, and corresponding flows at Little Falls gage. Locations are listed in Table 3-2 and Figure 2-8.

Station	Date, Time	Dissolved Oxygen, mg/l	pH Range	Flow, cfs
Little Falls Pool	8/28/02, 0120	4.9	7.8-9.2	892
Old Angler's Inn Pool	8/27/02, 0420	7.7	6.7-6.9	354
Aqueduct Dam	8/26/02, 2140	7	–	413
Seneca Pool	8/30/02, 0550	5	7.8-9.3	1890

4.0 MACROHABITAT SURVEY

4.1 METHODS

4.1.1 Development of Base Map

Several information sources were incorporated into the project mapping. For field maps, aerial photography was obtained from Air Photographics; the photographs were taken in November 2000, at a flow of 1200 mgd (1800 cfs). It was not possible to obtain additional aerial photography at lower flows since the study area is in restricted air space due to the events of September 11, 2001. Suitable satellite data taken during low flow periods also was not available in suitable locations or accuracy. The aerials from November 2000 provided the most recent overview of the river and were used to identify and map study area features.

The GIS base map was prepared using the November 2000 aerial photographs by reconciling them with local landmarks such as roads and buildings near the Potomac River channel. An overview of the base map is shown in Figure 4-1.

4.1.2 Field Habitat Mapping Procedures

Field personnel floated, canoed, or waded the study reach and recorded the macrohabitat mosaic on field maps prepared from the aerial photographs taken during fall 2000. The macrohabitat types and qualitative descriptions that guided the field assessment are listed in Table 4-1. Each macrohabitat type was drawn as a polygon by hand using visual determinations of the boundaries (relative to observable landmarks) between each habitat type. Determinations of shallow or deep runs were estimated by calibrated rod in areas of the channel that reflected the predominant character of the reach. Habitat polygons were individually labeled on field maps.

The macrohabitat mosaic and associated GPS and observational data were reviewed and subsequently digitized and used to create a GIS layer relative to the rectified aerial photographs.

Table 4-1. Macrohabitat descriptions in the Potomac River developed for the habitat assessment between Little Falls and Seneca Creek

Habitat Type	Code	Definition/Characteristics
Riffle	**Riffle**	Generally shallow (depths < 2 ft), swift reach with disturbed surface appearance
Shallow Run	**SRU**	Shallow reach (depths < 2 ft) with noticeable water velocity and smooth surface appearance
Riffle Shallow Run Complex	**R-SRU**	Extensive series of riffles formed by vertical underwater ledges alternating with shallow runs
Deep Run	**DRU**	Variable depth reach (depths > 2 ft) with noticeable water velocity and smooth surface appearance
Riffle Deep Run Complex	**R-DRU**	Extensive series of riffles formed by vertical underwater ledges alternating with deep runs
Pool	**Pool**	Variable depth reach (depths > 3 ft) with minimal to no water velocity and smooth surface appearance
Edge Pool	**EP**	Small pool typically located along a channel edge below a riffle or channel obstruction
Back Channel	**BC**	Secondary channel lacking flow adjacent to the river
Shoal	**Shoal**	Unvegetated gravel-cobble bar
Fall Complex	**Falls**	Large drop (greater than about 5 feet per foot) usually around large rocks and rock outcrops

4.2 MACROHABITAT RESULTS

Figure 4-2 shows an overview of macrohabitat in the study reach. Figures 4-3 through 4-24 show details of the macrohabitat mapping results. Table 4-2 lists the survey dates for various sections of the study reach and the daily average flow as measured at Little Falls Dam on those dates. Table 4-3 summarizes the acreage of the macrohabitat types for the study reach based on the 2002 survey results. The figures illustrate the very diverse nature of habitat in the study reach. The summary table shows the predominance of Pool (37%), Shallow Run (24%) and Deep Run (19%) habitats.

Table 4-2. Dates and flows (mid-day values except in October: daily average) for macrohabitat surveys in the Potomac River in 2002

Plate number	Dates	Flows, cfs
1	28-Aug, 3-Sep	1409, 1260
2	27-Aug	686
3	22-Aug, 27-Aug	304, 686
4	15-Aug, 19-Aug,20-Sep	486, 252, 413
5	13-Aug, 15-Aug,19-Aug, 18-Sep	660, 486, 252, 381
6	13-Aug, 21-Aug, 26-Aug	660, 468, 354
7	27-Aug	686
8	5-Sep	955
9	28-Aug, 5-Sep	1409, 955
10	28-Aug, 4-Sep, 8-Oct	1409, 1050, 1260
11	10-Oct	1370

Table 4-3. Total acreages and percent of riverine habitats in the Potomac River between Little Falls and Seneca Pool during low flow conditions

Habitat Code	Acres	Percent of Total
Pool	1013.1	36.84
Shallow Run (SRU)	648.2	23.57
Deep Run (DRU)	533.2	19.39
Riffle - Shallow Run (R-SRU)	156.6	5.69
Riffle	129.3	4.70
Not Characterized	86.3	3.14
Riffle - Deep Run (R-DRU)	36.8	1.34
Fall Complex	27.9	1.02
Dry	26.9	0.98
Deep Run (DRU) - Pool	26.2	0.95
Edge Pool (EP)	24.9	0.90
Shallow Run - Deep Run (SRU-DRU)	21.1	0.77
Rocks	17.7	0.65
Back Channel (BC)	2.1	0.08
Total (rounded)	**2750**	**100.00**

Table 4-4 summarizes the acreage of the macrohabitat types of the non-impounded reaches of the study area in comparison with an upstream non-impounded area. In the study reach, the predominant habitat types were Shallow Run (34%), Deep Run (28%), Pool (10%), Riffle-Shallow Run (8%) and Riffle (7%). In comparison, the upstream area with a lower gradient, the predominant habitat types were Deep Run (45%), Pool (28%), Shallow Run (14%) and Riffle (7%).

Table 4-4. Total acreages and percent of non-impounded habitats* in the Potomac River study area between Little Falls and Seneca Pool during low flow conditions in comparison to the riverine, non-impounded habitats in the vicinity of Potomac Dams 4 and 5 (Allegheny Energy, 2001). Flows during the macrohabitat assessment near Dams 4 and 5 ranged from 1,127 to 1,366 cfs and were conducted between July 8 and July 20, 2000.

Habitat Code	Little Falls to Seneca Pool		Potomac Dams 4 and 5	
	Acres	**Percent**	**Acres**	**Percent**
Pool	184.6	9.6	205.5	27.9
Shallow Run (SRU)	648.2	33.7	104.4	14.2
Deep Run (DRU)	533.2	27.8	330.7	44.9
Riffle - Shallow Run (R-SRU)	156.6	8.2	0.0	0.0
Riffle	129.3	6.7	47.8	6.5
Not Characterized	86.3	4.5	0.0	0.0
Riffle - Deep Run (R-DRU)	36.8	1.9	7.8	1.1
Fall Complex	27.9	1.5	0.0	0.0
Dry	26.9	1.4	0.0	0.0
Deep Run (DRU) - Pool	26.2	1.4	0.0	0.0
Edge Pool (EP)	24.9	1.3	7.5	1.0
Shallow Run - Deep Run (SRU-DRU)	21.1	1.1	0.0	0.0
Rocks	17.7	0.9	1.4	0.2
Back Channel (BC)	2.1	0.1	2.9	0.4
Tailwater	0	0.0	27.8	3.8
Total (rounded)	**1921.8**	100.1	**735.8**	100.0

* excluded pools in the study area were above Little Falls Dam, Aqueduct Dam and Dam 2 (Seneca Pool); the impoundments of Dams 4 and 5 were also excluded for this comparison.

Reference: Allegheny Energy Supply, 2001. Final Application for New License for Major Water Power Project - 5 MW or less. Dam 4 Hydroelectric Project Licensed Project No. 2516. Volume III - Studies. December 2001. Available on the web at http://esm.versar.com/pprp/bibliography/sec14.htm and at http://www.ferc.gov.

5.0 MICROHABITAT CHARACTERIZATION

Each of the habitat assessment study sections were mapped for potential collection of microhabitat information on transects up to a density of ten per mile. Appendix Table B-1 lists the coordinates of each transect which were used by field crews to locate the approximate start of each transect; Figures B-1 through B-11 show the starting points closest to the Maryland side of the shoreline, plotted on a stream GIS layer provided by Montgomery County Department of Environmental Protection. Transect locations were set at tenth-mile intervals perpendicular to an approximate channel center line at each location. Where the main channel was divided by islands as indicated in the GIS layer, multiple transect locations across the river were identified. Sampling was targeted to start when flows were less than about 1400 cfs (900 mgd) and to continue as long as flows remained below this level. Transects that were actually sampled in 2002 are shown on Figure 2-8.

5.1 COLLECTION OF MICROHABITAT INFORMATION IN SHALLOW AREAS (< ~ 5 FEET IN DEPTH)

Transects were sampled starting with every third transect which was feasible to sample based on safety considerations, staff and equipment availability, and water levels. Microhabitat measurements at each transect in these riverine sections were to be made at ten points per transect, where the transects crossed uninterrupted river channel. Transects in multiple-channel riverine sections, such as those associated with islands, were apportioned along the total width of the river channel. For example, microhabitat measurements were to be taken at five points in each channel of a transect bisected by an island. The exact number of microhabitat measurements varied depending on river conditions at the time of the survey. Digital photographs were taken at each transect across the channel (Maryland and Virginia sides); these photographs are available on the web site at http://esm.versar.com/pprp/potomac/2002report.htm.

Information collected at each point consisted of depth, water velocity, substrate determination, availability of nearby instream cover such as woody debris or vegetation (within a 50-ft radius), and general character of the adjacent riparian bank. Water velocity was measured at 0.2 and 0.8 times the depth in riverine areas 2.5 feet to about 6 feet in depth. Water velocity at riverine areas less than 2.5 feet was measured at 0.6 times the depth. General substrate character and embeddedness was determined visually if possible, and by plumbing with a weighted rope or probe in deeper areas to determine hard/soft bottom condition and substrate texture (large or small constituents). Position information was collected with a Garmin model GPSMap 76S handheld unit (stated accuracy with WAAS enabled, less than 3 meters). In some cases, distances from a known position were measured with a laser range finder with a 1- to 2-meter accuracy (Nikon Laser800 or Bushnell Yardage Pro). A sample field sheet is shown in Table 5-1. Data values were entered into an Access database.

Table 5-1.

Potomac Microhabitat Field Sheet

Data on Back: ________ | Picture # MD:______ Picture # VA: ______

			Z > 0.5m		**Z < 0.5m**	**Substrate**	**Embeddedness**	**Structure**	**Cover**
Transect: ___________	Distance from Initial Point (m)	Depth (m)	Velocity @ 0.2 (m/s)	Velocity @ 0.8 (m/s)	Velocity @ 0.4 (m/s)	sand/silt, gravel/cobble, boulder/bedrock	0-25%,25-50%, 50-75%,75-100%	PBAR, BLDR, H LEDGE, LOG, BEDOUT	EVEG, SAV, WD
Crew: ___________									
Date: __________ **Time:** __________									
Range (m) ________ **Bearing** ______									
Interval (Range/10): ________									
Elevation (m) __________									
MD shore									
Dominant BankCover									
modified bank, overhanging vegetation, sheer cliff, vegetated to bank									
Run/Rise to water edge: ___________									
Run/Rise at bank: ________________									
Lat. (d mm.mmm)_______ ________									
Lon. ________ ________									
VA shore									
Dominant BankCover									
modified bank, overhanging vegetation, sheer cliff, vegetated to bank		Benchmark Location: ______________________ Pre: Lat.______________ Long._______________ Post: Lat._______________ Long._____________ Presample Elevation: ______________________ Post sample Elevation: _____________________					for boulder/ bedrock=0% for sand/silt=100%	point bar, boulder, horizontal ledge, log, bedrock outcrop	emergent vegetation, SAV beds, woody debris
Run/Rise to water edge: ___________									
Run/Rise at bank: ________________									
Lat. ________ ________									
Lon. ________ ________									
Other Features	access trail, boat launch, bridge pier, cliff, dock, fish pot, picnic area, powerline, rock ledge, water intake structure								

5.2 BATHYMETRIC MAPPING OF POOLS

Bathymetric data of major pools deeper than about 5 feet were collected by battery powered canoe in several areas (see Table 5-2) using a two-person crew. One crew member operated the mapping equipment while the other steered the boat. The mapping equipment consisted of a Lowrance Model LCX-15MT sonar unit with GPS and multimediacard (MMC) for electronically recording depth and location information. The sonar transducer used was a 200 kHz skimmer transducer mounted to the side of the canoe. The GPS receiver used was a model LGC-12S for the Little Falls Dam Pool. It was then replaced by a more accurate WAAS model LGS-12W receiver for subsequent bathymetric measurements, with a stated accuracy of under 3 meters. Depths were checked periodically with a calibrated measuring pole in depths of 10 feet or less and were within 4 inches of the measuring pole. The raw bathymetric and position data were processed with a program called slg2txt supplied by Lowrance. This program produced a text file containing depth and position information which was plotted by transect within Excel following conversion of position information into distance across or along the river channel. Terrain Navigator version 5.03 (Maptech Inc., Amesbury, MA) was used to plot position information onto sections of USGS topographic maps (Maptech® USGS Topographic Series™, ©Maptech®, Inc. 978-933-3000, www.maptech.com/topo).

Table 5-2. Bathymetric sampling locations in the Potomac River flow-by study reach

Pool Name	Description	Transect Numbers
Little Falls Dam Pool	Upstream of Little Falls Dam to Ruppert Island	13 - 22A
American Legion Bridge Pool	Beneath the American Legion Bridge, from Dots Island to Stubblefield Falls	41 - 51
Old Angler's Inn Pool	Vicinity of boat ramp at Old Angler's Inn between Offutt and Sherwin Islands	73 - 79A
Mather Gorge Pool	Mather Gorge from lower end of Bear Island upstream to Rocky Islands	82 - 95A
Aqueduct Dam Pool	Upstream of Aqueduct Dam to Bealls Island	112 - 117
Seneca Pool*	Upstream of Dam No. 2 rubble to Sharpshin Island	177 - 194

*Due to thick SAV beds, sonar could not be used in this area. Ten points per transect were sampled using a measuring rod and the location mapped with a hand-held Garmin 76S GPS unit.

5.3 RESULTS

Figures 5-1 through 5-24 illustrate bathymetric data and transect location information collected by sonar and GPS, in pool areas of the Potomac River study reach, from Little Falls Dam, beneath the American Legion Bridge, the Old Angler's Inn area, Mather Gorge and Aqueduct Dam Pool. Figures 5-25 through 5-27 illustrate bathymetric data collected by measuring pole and transect location information collected by GPS in Seneca Pool. Figures 5-28 through 5-37 illustrate depth and velocity information collected in various shallow reaches of the Potomac River study area. Appendix D illustrates all of the bathymetric data plotted on the same scale for comparison.

Table 5-3 lists the average depths of the major pool areas, determined by averaging all of the sonar or otherwise measured depth readings from transverse transects in each of those pool areas. Although the transects are not necessarily equally spaced in these pool areas, these results give some indication of the overall depth in these areas. Results indicate that the pool beneath the American Legion Bridge is quite deep, averaging over 20 feet overall, 40 feet in the main channel, and reaching 94 feet at its maximum depth. Mather Gorge and Old Angler's Inn Pools are both also relatively deep, with average main channel depths 23 and 22 feet, respectively, and with maximum depths of 45 and 36 feet, respectively. The remaining large pool areas are relatively shallow, with maximum depths less than 15 feet and average depths less than 8 feet. Average depth and velocity (where measured) for each transect are listed in Table 5-4.

Table 5-3. Average depth of major pool areas in the Potomac River during low flow conditions, from Seneca Pool to Little Falls Dam.

Pool Area	Average Depth, feet	Average Depth of Main Channel, feet	Maximum Depth, feet	Flow, cfs
Seneca	5.2	Not measured	7.6	1370
Aqueduct Dam	6.3	6.7	14.8	395
Mather Gorge	17.7	22.7	44.8	310
Old Angler's Inn	9.9	22.4	36.3	285
American Legion Bridge	20.8	40.3	94.1	1330
Little Falls Dam	7.8	Not measured	13.5	468

Table 5-4. Average depth and velocity (where sampled) along transects in the Potomac River from Seneca Pool to Little Falls Dam.

Transect	Average Depth, feet	Average Velocity, fps
Little Falls Dam		
Snake Island Transect	8.0	
13	9.3	
14	9.4	
15	8.8	
16	8.4	
17	8.1	
18A	7.8	
19A	6.3	
20	5.8	
21A	5.6	
22A	2.7	
American Legion Bridge Pool		
Longitudinal Transect: American Legion Bridge Pool	40.2	
40B	3.7	
41	11.6	
42	38.3	
43	40.5	
44A	33.4	
45A	32.8	
46	22.2	
47	21.3	
48	21.2	
49	11.7	
50	19.5	
51	15.8	
52	12.4	
53	11.7	
Stubblefield Falls to Offutt Island		
55	2.2	0.22
58	1.7	0.54
61	6.1	0.05
64	1.1	1.36
70	1.2	0.22

Table 5-4. (Continued)

Transect	Average Depth, feet	Average Velocity, fps
Old Angler's Inn Pool		
Channel Center Old Angler's Inn Pool 1	16.1	
Channel Center Old Angler's Inn Pool 2	22.4	
73	4.2	
74	8.8	
75	10.1	
76	9.2	
77A	11.2	
78A	21.8	
79A	9.7	
81A	7.2	
82	9.4	
Mather Gorge		
Mather Gorge Longitudinal Transect 2	22.6	
Mather Gorge Longitudinal Transect 1	22.7	
83	17.6	
84	32.5	
85	28.6	
86	16.7	
87	25.9	
88	24.2	
89	13.1	
90	9.9	
91	7.0	
92	3.2	
93	19.5	
94B	11.5	
95A	10.3	
Transect between 95A and 94B	11.5	
Longitudinal Transect at Rocky Island	11.5	

Table 5-4. (Continued)

Transect	Average Depth, feet	Average Velocity, fps
Aqueduct Dam Pool		
Aqueduct Dam Pool Longitudinal Transect, Section 1	7.4	
Aqueduct Dam Pool Longitudinal Transect, Section 2	6.0	
Aqueduct Dam Pool Longitudinal Transect, Section 3	6.4	
Transect 103 to intake area	6.6	
103	5.7	
105	5.5	
106-1	4.9	
106-2	5.2	
106A	9.4	
107A	9.4	
108	6.9	
109	5.5	
Transect 110 from MD Shore to Center of Channel	5.7	
Transect 110 from VA shore to Center of Channel	7.3	
111	6.6	
112	6.7	
113	5.9	
114	5.6	
115	5.5	
116	4.4	
Watkins Island area		
118	2.1	1.00
121	3.7	0.76
124	2.4	0.73
127	5.1	0.20
149	7.0	0.30
152	5.4	0.27
155	2.4	0.19
157	2.4	0.22
158	7.5	0.53
161	7.4	0.57

Table 5-4. (Continued)		
Transect	**Average Depth, feet**	**Average Velocity, fps**
Seneca Pool		
177	5.0	
178	5.1	
179	5.3	
180	5.8	
181	5.5	
183	5.1	
186	5.1	
190	5.0	
194	4.8	

6.0 LIVING RESOURCES

Lists of biota found in the Potomac River study area are provided in the following tables.

Table 6-1. Comparison of fish species collected below Great Falls on Potomac River by electrofishing (E) and seining (S), 1999 and 1997.

Common	**Scientific**	**1999E**	**1997E**	**1997S**
American Eel	*Anguilla rostrata*	X	X	
Gizzard Shad	*Dorosoma cepedianum*	X	X	
Spotfin Shiner	*Cyprinella spilopterus*			X
Carp	*Cyprinus carpio*	X	X	
River Chub	*Nocomis micropogon*			X
Silverjaw Minnow	*Notropis buccatus*			X
Spottail Shiner	*Notropis hudsonius*			X
Bluntnose Minnow	*Pimephales notatus*			X
Quillback	*Carpiodes cyprinus*	X	X	X
Northern Hog Sucker	*Hypentelium nigricans*	X	X	
Golden Redhorse	*Moxostoma erythrurum*	X	X	
Shorthead Redhorse	*Moxostoma macrolepidotum*	X		
Channel Catfish	*Ictalurus punctatus*		X	
Redbreast Sunfish	*Lepomis auritus*	X	X	X
Warmouth	*Lepomis gulosus*	X		
Pumpkinseed	*Lepomis gibbosus*			X
Bluegill	*Lepomis macrochirus*	X	X	X
Longear Sunfish	*Lepomis megalotis*			X
Smallmouth Bass	*Micropterus dolomieu*	X	X	X
Largemouth Bass	*Micropterus salmoides*	X	X	X
Greenside Darter	*Etheostoma blennioides*			X
Tessellated Darter	*Etheostoma olmstedi*			X
Walleye	*Stizostedion vitreum*	X	X	

Table 6-2. List of species found during a survey of species composition and density of each bed above Great Falls from Seneca Dam upstream to Whites Ferry (conducted by USGS) and below Great Falls from Chain Bridge downstream to Mount Vernon, Virginia (conducted jointly by U. S. Geological Survey, National Research Program and D.C. Department of Health, Fish and Wildlife Division). The survey was conducted by boat between August and September 2001 and 2002. For 2001 below Great Falls, percent cover of each species (disregarding bed density) is shown in parentheses. The 2001 coverage was based on a boat survey because aerial photography near Washington D.C. was not available in 2001.

Species (Latin name)	**Common name**	**Above Great Falls 2001**	**Above Great Falls 2002**	**Below Great Falls 2001**	**Below Great Falls 2002**
Hydrilla verticillata	Hydrilla	Yes	Yes	Yes (46%)	Yes
Vallisneria americana	Wild celery	Yes	Yes	Yes (14%)	Yes
Najas minor	None	No	No	Yes (4%)	Yes
Najas guadalupensis	Southern naiad	Yes	Yes	Yes (8%)	Yes
Myriophyllum spicatum	Eurasian water milfoil	Yes	Yes	Yes (10%)	Yes
Stuckenia pectinata (formerly *Potamogeton pectinatus*)	Sago pondweed	No	No (but was found at Point of Rocks)	No	No
Potamogeton perfoliatus	Redhead grass	No	No	No	No
Potamogeton pusillus	Slender pondweed	No	No	No	No
Potamogeton crispus	Curly pondweed	No	Yes	Yes (<1%)	No
Ceratophyllum demersum	Coontail	Yes	Yes	Yes (15%)	Yes
Heteranthera dubia	Water stargrass	Yes	Yes	Yes (4%)	Yes
Zannichellia palustris	Horned pondweed	No	No	No	
Total number of species found during the SAV survey from the boat		6	7	8	7

Table 6-3. List of submersed aquatic plants found in the tidal Potomac River and Estuary, 1985-1997, Chain Bridge downstream to Maryland Point, Maryland. The survey was conducted by boat between August and September by the U. S. Geological Survey, National Research Program, and the Washington D.C. Department of Health, Fish and Wildlife Division. Classification and nomenclature derived from: Godfrey and Wooten 1981; United States Department of Agriculture, Natural Resources Conservation Service, Plants database.

Family	Species	Common name
Hydrocharitaceae (frogbit)	*Hydrilla verticillata* (L. F.) Royle	Hydrilla
	Vallisneria americana Michaux	Wild celery
Najadaceae	*Najas minor* Allioni	
	Najas guadalupensis (Sprengel) Magnus	Southern naiad
Haloragaceae (water milfoil)	*Myriophyllum spicatum* L.	Eurasian water-milfoil
Potamogetonaceae (pondweed)	*Stuckenia pectinatus* (L.) Boerner (formerly *Potamogeton pectinatus* L.)	Sago pondweed
	Potamogeton perfoliatus L.	Redhead grass
	Potamogeton pusillus L.	Slender pondweed
	Potamogeton crispus L.	Curly pondweed
Ceratophyllaceae (coontail)	*Ceratophyllum demersum* L.	Coontail
Pontederiaceae (pickerelweed)	*Heteranthera dubia* (Jacquin) MacMillan	Water stargrass
Zannichelliaceae	*Zannichellia palustris* L.	Horned pondweed

Table 6-4. Qualitative survey data of freshwater mussels in the Potomac River by Maryland Natural Heritage personnel in 1993-1994

River	Map Quad	Species	Site Description
Potomac	Keedysville	*Elliptio complanata*	50 M downstream of Antietam Creek to 10 M above Antietam Creek
Potomac	Charles Town	*Elliptio complanata*	Began at Huckleberry Hill Campground, continued upstream 100 yd (Huckleberry Hill Campground is 0.6 MI upstream of dam #3)
Potomac	Charles Town	*Elliptio complanata* *Lampsilis* species	Surveyed an area of 200 yd at 0.1 MI upstream of dam #3 (0.5 MI downstream of Huckleberry Hill Campground)
Potomac	Harpers Ferry	*Elliptio complanata* *Lampsilis* species	Channel on inside of island starting from the boat ramp working upstream 260 YD
Potomac	Harpers Ferry	*Elliptio complanata* *Lampsilis* species	Island downstream of Brynes Island, starting from the downstream tip of island, 125 yd on MD side of island, 175 on WV side
Potomac	Harpers Ferry	*Elliptio complanata* *Lampsilis* species	Surveyed from 50 M below creek up to mouth of creek, surveyed small island downstream of mouth.
Potomac	Point of Rocks	*Elliptio complanata* *Lampsilis* species	40 M downstream of Catoctin on Potomac continuing until 50 M upstream of Catoctin, including small island downstream of creek
Potomac	Point of Rocks	*Elliptio complanata* *Lampsilis* species *Strophitus undulatus*	Island at the upstream side of the mouth of Catoctin. Surveyed 2/3 OF ... Btwn island and mainland, began at creekside
Potomac	Point of Rocks	*Elliptio complanata* *Lampsilis* species	Island downstream of the mouth of Little Catoctin Creek. Island is approximately 50 M and 25 M upstream of island
Potomac	Point of Rocks	*Elliptio complanata* *Lampsilis* species	Started survey 50 yd downstream of upstream tip of Mason Island, on both sides of the island (VA/Mason channel and MD/Mason channel). Surveyed upstream 100 yd to 50 yd upstream of island (total 100 yd).

Table 6-4. Continued

River	Map Quad	Species	Site Description
Potomac	Point of Rocks	*Elliptio complanata* *Lampsilis* species	Starting 75 yd downstream of Washington Run, surveyed upstream to 50 yd upstream of Washington Run (125 yd total).
Potomac	Point of Rocks	*Elliptio complanata* *Lampsilis* species	Surveyed around small island 200 yd upstream of Paton Island. Began survey 15 yd below downstream tip of small island, surveyed upstream 60 yd above downstream tip in channel closer to MD and 75 yd above downstream tip in channel closer to VA
Potomac	Poolesville	*Elliptio complanata* *Lampsilis* species	Channel between Nolands Island and small island (toward middle of Nolands Island). Started 90 yd downstream of upstream tip of small island. Surveyed upstream to 10 yd above island (total of 100 yd).
Potomac	Poolesville	*Elliptio complanata* *Lampsilis* species	Mason Island, upstream end and small island near MD shore
Potomac	Poolesville	*Elliptio complanata* *Lampsilis* species	Mouth of Monocacy River to mouth of Little Monocacy River
Potomac	Poolesville	*Elliptio complanata* *Lampsilis* species	Near Dickerson Regional Park, 300 yd up and downstream from mouth of small creek at parking area
Potomac	Poolesville	*Elliptio complanata* *Lampsilis* species	Shoal between Mason Island and MD side of river, near creek then transversely partition Mason Island (300 yd upstream, 150 yd downstream).
Potomac	Poolesville	*Elliptio complanata* *Lampsilis* species	Started 50 yd downstream of the Monocacy, surveyed upstream to 125 yd upstream of the Monocacy (total 175 yd)
Potomac	Poolesville	*Elliptio complanata* *Lampsilis* species	Island downstream of Tuscarora Creek starting from downstream tip of island, surveying upstream to 50 yd of Tuscarora Creek. Lower half of channel between island and MD bank not surveyed due to deep water
Potomac	Waterford	*Elliptio complanata* *Lampsilis* species	Downstream end of Mason Island and shoals between island and MD shore of Potomac

Table 6-4. Continued

River	Map Quad	Species	Site Description
Potomac	Waterford	*Elliptio complanata* *Lampsilis* species	Near Mason Island, middle of three other islands at downstream end near MD side
Potomac	Waterford	*Elliptio complanata* *Lampsilis* species	Sandbar-island (200 ft near MD shore, across from head of Harrison Island up to boatramp
Potomac	Waterford	*Elliptio complanata* *Lampsilis* species	South of Harrison Island between island and VA shore, downstream of small ferry boat
Potomac	Seneca	*Elliptio complanata* *Lampsilis* species	Potomac River and Sycamore Island, near Watkins island
Potomac	Seneca	*Elliptio complanata* *Lampsilis* species	Potomac River Shoals area from mouth of Muddy Run downstream 400 yd
Potomac	Rockville	*Elliptio complanata* *Lampsilis* species	Potomac River at small islands between Gladys and Beals Island, near MD shore
Potomac	Rockville	*Elliptio complanata* *Lampsilis* species	Potomac River at upstream end of Conn Island
Potomac	Rockville	*Elliptio complanata* *Lampsilis* species	Shoals NW of Beals Island
Potomac	Vienna	*Elliptio complanata* *Elliptio producta* *Lampsilis* species *Strophitus undulatus*	Olmstead Island at extreme upstream end between VA side and first rivulet that flows through island
Potomac	Falls Church	*Elliptio complanata*	Cedar Island (downstream end) to Cabin John Island
Potomac	Falls Church	*Elliptio complanata* *Lampsilis* species	High Island to MD shore
Potomac	Falls Church	*Elliptio complanata* *Lampsilis* species *Pyganodon cataracta*	Offut Island to MD shore, small island between Offut and Hermit Island.
Potomac	Falls Church	*Elliptio complanata* *Lampsilis* species	Plummers Island
Potomac	Falls Church	*Elliptio complanata* *Lampsilis* species	SE end of Bear Island on Billy Goat Trail

Table 6-4. Continued

River	Map Quad	Species	Site Description
Potomac	Falls Church	*Elliptio complanata* *Lampsilis* species *Strophitus undulatus*	Potomac River at Bear Island near Billy Goat Trail, small beach below bluff on island 400 YDS from trail head
Potomac	Falls Church	*Elliptio complanata* *Lampsilis* species	Potomac River, between river and feeder dam above Lock 6. Surveyed overflow *Pyganodon cataracta* areas.
Potomac	Falls Church	*Elliptio complanata* *Pyganodon cataracta*	Swaindon's Island to MD shore
Potomac	Falls Church	*Elliptio complanata* *Lampsilis* species	Vaso Island to MD shore at Carderock Recreation Area
Potomac	Washington West	*Elliptio complanata* *Lampsilis* species	Chain Bridge flats, 50 yd above and below Chain Bridge (100 yd total)
Potomac	Washington West	*Elliptio complanata* *Lampsilis* species	Fletchers Cove at Fletchers Boat rental, plus 100 yd upstream